Long-term results after two-stage operative treatment of late developmental displacement of the hip

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Abstract The purpose of this study was to evaluate the long-term results of 43 patients who underwent two-stage operative treatment of late developmental displacement of the hip (LDH). The average age at the time of open reduction was 20.7 months. An intertrochanteric osteotomy was performed after an average of 6.7 weeks. The mean clinical and radiological follow-up was 32.75 years. Degenerative changes were documented according to Kellgren. For assessment of outcome we used Severin's classification and score according to Merle d'Aubigné. One patient required a total hip replacement. Complications included one superficial infection and three recurrent dislocations. One patient developed coxa magna and two additional avascular necrosis of the hip. The score according to Merle d'Aubigné was 16.1. At the latest follow-up 35 hips had degenerative changes grade 0 or 1 and 7 grade 2. Using the Severin classification 13 hips had a satisfactory result (class I), 14 were rated as class II, 7 as class III, 5 as class IV and 2 as class V. The two-stage procedure seems to be a successful principle in the operative treatment of LDH.

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Résumé Le but de l'étude est d'évaluer le résultat à long terme du traitement chirurgical en deux temps de la luxation congénitale de la hanche découverte tardivement. L'âge moyen à la réduction chirurgicale était de 20,7 mois. Une ostéotomie intertrochanterienne a été faite 6,7 semaine plus tard. Le recul moyen était de 32,75 ans. Les lésions dégénératives ont été classées selon Kellgren; l'étude des résultats selon la classification de Severin et la cotation de Merle d'Aubigné. Les complications comprenaient une infection superficielle et 3 récurrences de luxation. Un patient développa une coxa magna et deux une ostéonécrose. Le score de Merle d'Aubigné était de 16,1. Au dernier recul 35 hanches avaient une arthrose. Selon la classification de Severin 13 hanches avaient un résultat satisfaisant coté I, 14 étaient cotées II, 7 étaient cotées III, 5 étaient cotées IV et 2 étaient cotées V. La chirurgie en deux temps apparaît comme une bonne méthode de traitement.

Introduction

The management of developmental dysplasia of the hip is aimed at early diagnosis and treatment. The pathological changes occurring in a dysplastic hip in a newborn infant are generally reversible, with a 95% rate of success with simple means of treatment such as a Pavlik harness or other methods of maintaining reduction at an early age [9, 11, 13]. It is claimed that adequate acetabular remodelling is possible only during the first 18 months of life. After this, satisfactory development cannot always be assured by non-operative treatment following closed reduction [4]. Many methods for operative treatment of late developmental displacement of the hip have been published. The choice of operative procedure for the reduction of a congenitally dislocated hip is controversial. Some investigators have compared the advan-

tages of an anteromedial approach with those of an anterolateral approach, but there is a lack of substantive data to support any specific operative approach [9, 11, 18]. Advocates of an anteromedial [7, 15] procedure have reported that this approach is less invasive and results in less stiffness of the joint, the major obstacles to reduction are easy to reach and to correct, damage to the iliac apophysis and the abductor muscles is avoided, dissection is minimal with negligible blood loss, both hips can be operated on safely in a single operative session and the scar is cosmetically acceptable [11]. However, the various anteromedial approaches have also been criticised because of poor visualisation of the acetabulum, the associated risk of damage to the medial circumflex vessels and the inability to perform capsulorrhaphy or concurrent secondary procedures [7, 11, 18]. It is difficult to predict the long-term results following operative or non-operative treatment as the results of open and closed treatment for children diagnosed over the age of 12 months vary [1, 4]. The purpose of this study was to evaluate the long-term results of two-stage operative treatment of late developmental displacement of the hip (LDH).

Material and method

We reviewed the charts of 43 patients who had been managed with open reduction through an anterolateral approach for congenital dislocation of the hip followed as a second step by intertrochanteric osteotomy at the Orthopaedic Hospital Rummelsberg with a minimum follow-up of 30 years. All patients were followed up 1, 5, 10, 15 and a minimum of 30 years after the index operation. Patients who had a neuromuscular or teratological dislocation had been excluded previously. The average age of the children at the time of open reduction was 20.7 months (min.: 9, max.: 66). Via a lateral approach an intertrochanteric osteotomy with derotation and varus osteotomy was performed after an average of 6.7 weeks (min.: 4, max.: 12). There were 39 girls and four boys; the affected hips were left-sided in 26 and right-sided in 17. The mean follow-up from operation to the latest review was 32.9 years (min.: 30, max.: 37.9). We graded preoperative subluxation or dislocation according to the Tönnis [22] classification, in which the centre of the ossific nucleus of the femoral head is related to Perkins' line and to a horizontal line at the level of the lateral margin of the acetabulum [5]. Two of the hips were classified as grade 1, 11 as grade 2, 14 as grade 3 and 11 as grade 4.

Surgical technique

Open reduction was performed if a stable and concentric reduction could not be achieved by closed means as

demonstrated with arthrography using CO₂. Operations were performed in a supine position. An anterolateral approach between the sartorius and the tensor muscle was used in all cases. The capsule was opened through a T-shaped incision. A redundant capsule was excised and a capsulorrhaphy performed in all cases. All patients had iliopsoas tenotomies. The ligamentum teres was noted to be hypertrophic or redundant in 37 hips and was resected. In 37 hips, the transverse acetabular ligament was resected, too. The pulvinar in the acetabulum was removed in all cases. Following three incisions the limbus (2, 6 and 11 o'clock) was everted. An excision of the whole limbus was never performed. The head was then reduced and the joints evaluated for stability and antetorsion. After that closure of all soft tissue layers with repair of the muscles was performed. After operation, the hips were immobilised in a bilateral hip spica in the position of maximum stability, e.g. 10–15° flexion, 30–40° abduction and 30–50° internal rotation until the corrective osteotomy. Intertrochanteric osteotomy was performed after an average of 6.7 weeks. Immobilisation using a bilateral hip spica was applied for an additional eight weeks. Afterwards a night splint was used for an additional two years. The metal was removed after six months. Today we use the same operative procedure, but use an orthosis made from carbon fibres instead of a splint in the shape of a bilateral hip spica.

Radiological assessment

The radiographic series of the operated hip for each patient was analysed. The assessments were made at the initial presentation, at 1, 5, 10 and 15 years and at the last review.

Pre-reduction roentgenograms were evaluated with regard to the grade of displacement according to Tönnis [22], the presence of the femoral epiphyseal ossification centre, Shenton's line [8] and the acetabular angle of Sharp [17].

The acetabular angle and disruption of Shenton's line were assessed 1 and 5 years after initial treatment. At the ten-year follow-up, the centre-edge angle of Wiberg [24], Sharp's angle and CCD angle were measured.

At the 15-year follow-up and the latest follow-up the centre-edge angle of Wiberg and CCD angle were measured and dislocation according to Crowe documented [2]. Additionally at the latest follow-up degenerative changes of the hip were documented according to Kellgren [6]. For assessment of outcome we used the classification of Severin (Table 1) [16].

Complications were also documented. Clinical evaluation at the latest follow-up included leg length discrepancies, score according to Merle d'Aubigné [10] and range of motion (ROM).

Table 1 Radiological assessment according to Severin [16]

Category	Description
Class I	Normal hips; in adults, the centre-edge (CE) angle of Wiberg over 25°; in children aged 6–14 years, CE angle over 15°
Class II	Mild deformity of head or neck, but the hip otherwise deeply and concentrically reduced; CE angle as in class I
Class III	Dysplastic hips without subluxation; CE angle less than 20° in adults and less than 15° in children
Class IV	Subluxation
Class V	The head articulating with a secondary acetabulum in the upper part of the original acetabulum
Class VI	Redislocation

Results

The postoperative complications included one superficial wound infection and three recurrent dislocations requiring revision open reduction. One patient developed coxa magna and two additional hips avascular necrosis of the hip (AVN). One patient required a total joint replacement. Trendelenburg's sign was positive in five patients. The score according to Merle d'Aubigné was 16.1 (min.: 12, max.: 18). At the time of follow-up no patient had pain at rest, used crutches or a cane or needed analgesics for pain relief. Flexion averaged 115° (range: 60–130°), the flexion contracture 1.2° (range: 0–15°), abduction 34° (range: 0–50°), adduction 18° (range: 0–30°), internal rotation 12° (range: 0–35°) and external rotation 19° (range: 0–40°).

The average limb length discrepancy was 0.8 cm (range: 0–4 cm). In 30 patients the limb length discrepancy was between 0 and 1.0 cm. In this group the mean score

according to Merle d'Aubigné was 16.6. In nine patients the limb length discrepancy was between 1.0 and 2.0 cm. In this group the mean score according to Merle d'Aubigné was 16.0. In four cases the limb length discrepancy was between 2.0 and 4.0 cm. In this group the mean score according to Merle d'Aubigné was 16.0. In all cases a good or excellent result could be achieved. There was a tendency for a slightly better score according to Merle d'Aubigné in cases with an equal limb length, which was not clinically relevant. In the cases with limb length discrepancies over 1.0 cm shoe modifications were used.

Radiological assessment

The results of the radiological assessment made at the initial presentation, at 1, 5, 10 and 15 years and at the last review are presented in Table 2.

At the latest follow-up according to the classification of Crowe 41 hips were grade 1 and 1 hip grade 2.

According to the Kellgren and Lawrence score, 35 hips had no or doubtful signs of osteoarthritis (grade 0 or 1). Seven hips had mild osteoarthritis (grade 2).

Using the Severin classification for radiographic outcome, 13 of the hips had a satisfactory result with Severin class I and 14 hips with class II; seven hips were rated as class III, five hips as class IV and two hips as class V.

Figure 1 presents the case of 34-year-old woman with a follow-up of 32.7 years. The index operation was performed at the age of nine months. At the latest follow-up she has no complaints, there is no leg length discrepancy, ROM is extension/flexion 0/0/120, abduction/adduction 40/0/30 and external/internal rotation 40/0/25°. Trendelenburg's sign is negative. Nevertheless there are degenerative changes classified as grade 1 according to Kellgren.

Table 2 Results of radiological assessment

	Preoperative	1 year	5 years	10 years	15 years	Latest follow-up
Presence of the femoral epiphyseal ossification centre	Pos.: 33 Neg.: 10					
Menard-Shenton line	Pos.: 25 Neg.: 18	Pos.: 25 Neg.: 18	Pos.: 32 Neg.: 11			
Acetabular angle (Sharp)	Ø: 35.8° Min.: 50° Max.: 28°	Ø: 29.4° Min.: 20° Max.: 40°	Ø: 21.0° Min.: 8° Max.: 34°	Ø: 12.6° Min.: 2° Max.: 32°		
Centre-edge angle (Wiberg)				Ø: 31.3° Min.: 18° Max.: 38°	Ø: 34.0° Min.: 20° Max.: 60°	Ø: 32.4° Min.: 18° Max.: 50°
CCD angle				Ø: 133.4° Min.: 148° Max.: 118°	Ø: 131.7° Min.: 146° Max.: 110°	Ø: 134.5° Min.: 142° Max.: 120°

Fig. 1 Radiographic series of a patient with a good outcome after 30 years. **a** Radiograph made before open reduction, showing a high dislocated hip. **b** Radiograph made 1 week after an open reduction. **c** Radiograph made 2 weeks after femoral intertrochanteric derotation and varus osteotomy showing adequate reduction. **d** Radiograph made 15 years postoperatively, showing the femoral head within the remodelled acetabulum. **e** Radiograph made 30 years postoperatively, showing the femoral head within the remodelled acetabulum. The radiographic result was graded as Severin class I, and the degenerative changes were rated as grade 1 (minimum changes)

Discussion

The goals of management of children who have congenital dislocation of the hip are concentric reduction and maintenance of the reduction in order to provide the optimum environment for development of the femoral head and the acetabulum, to restore normal anatomy and to reduce the risk of the development of premature degenerative arthritis [1, 3, 4, 7, 9, 11, 12, 19–21, 25]. If the diagnosis is made within the first few weeks of life, the rate of success associated with use of a Pavlik harness or another abduction device is very high [11]. According to Angliss et al. [1] we called our indication for operative treatment of dislocated hips “late developmental displacement of the hip”. Nowadays developmental displacement of the hip can be diagnosed within the very first days after birth via ultrasound. In that way we follow Angliss et al. and personally prefer the term LDH for every dislocated hip which has not been recognised within the first six months. We know that there is extensive discussion of when one should talk about LDH. We fully agree with other authors that the earlier treatment of developmental displacement of

the hip starts, the better the results will be. In our study there was a wide age range of the patient at the index operation (9–66 months). In three cases age at the index operation was 56, 59 and 66 months. In all other cases the range was 9–30 months. In the case of the female patient with the index operation at the age of 59 months a total hip replacement was necessary; in all other cases an excellent result was achieved.

A congenitally dislocated hip cannot always be reduced with closed methods. In these situations, several operative procedures have been proposed for reduction. Morcuende et al. [11] postulated that with an anteromedial approach for open reduction there is direct access to the obstacles to reduction and the iliac apophysis and the abductor muscles are left undisturbed. Using our anterolateral approach all obstacles could be treated easily, too. Psoas tenotomy and adductor tenotomy were performed if necessary in our patients; nevertheless, it should be remembered that psoas tenotomy may endanger the circumflex vessels [1]. In our series we found no problems resulting from the above-mentioned tenotomies. The reported prevalence of growth disturbances of the femoral head after an anteromedial

approach has ranged from 0 to 67% [11]. Morcuende et al. [11] reviewed the long-term results of open reduction of the hip via a medial approach. The demographics of their study are similar to our own. They describe the results of dislocations presenting at a mean age of 14 months and followed for a mean of 11 years (4–23). Our study showed a low incidence of AVN. One patient developed coxa magna and two additional hips AVN. Hypertrophy of the femoral head is considered to be overgrowth secondary to increased blood flow at the proximal side of the femur due to incision of, for example, the joint capsule or osteotomy. In the study of Nakamura et al. [12], such hypertrophy was observed in all patients after 1–2 years after operation. In the study of Angliss et al. [1], the incidence of AVN appeared comparatively high with only 34 of 191 hips showing no epiphyseal change. Long-term follow-up [3] after an antero-lateral approach preceded by traction and with excision of the limbus and subsequent derotation osteotomy demonstrated that the epiphyseal angle became progressively more horizontal in 32 (22%) of 147 hips as the hip developed. Ryan et al. [14] reviewed the results of operative treatment of congenital dislocation of the hip in 18 children (25 hips) whose average age at the time of the index operation was 6 years and 4 months (range: three years to 9 years and 11 months). Sixteen hips had an excellent result, seven a good result and two a fair result. The average limb length discrepancy was 0.8 cm (range: 0–4 cm). According to Severin's classification of the radiographic appearance, seven hips had an excellent result, 11 a good result, four a fair result and three a poor result. Of 11 hips that had evidence of osteonecrosis of the proximal part of the femur four had a severe deformity, and one patient had radiographic evidence of moderate degenerative osteoarthritis when she was 16 years old. Ryan et al. [14] suggested that a one-stage operative procedure consisting of open reduction, femoral shortening and pelvic osteotomy (if necessary) for previously untreated congenital dislocation of the hip in children who are three to ten years old can result in remodelling of the acetabulum and a functional hip.

With regard to intractable DDH resistant to conservative treatment such as Pavlik harness and overhead traction, there are many reports suggesting that the long-term results of open reduction are poor. In particular, development of AVN poses a problem. Because of different operating techniques and evaluation criteria, it has been difficult to make simple comparisons. However, AVN is reported to occur in between 15 and 43% of cases.

It appears that a combination of open reduction and femoral osteotomy is indicated for older children who exhibit dislocation at a higher position [12]. Of the 11 joints Nakamura et al. studied, six required subsequent corrective surgery on the acetabular side. In our series in only one case was a shell plasty performed at the index operation.

With our method of management, moderate to severe osteoarthritis developed in 40% of dislocated hips reviewed at a mean of 33 years. Haidar et al.'s review [4] suggests that acceptable results are produced by combined open reduction and Salter innominate osteotomy for the late presentation of developmental dysplasia or failed previous treatment. We found good or excellent clinical results in all but one hip. It seems probable that even without pelvic osteotomy the acetabulum would have remodelled in some cases during growth after concentric reduction and a prolonged period of postoperative splintage. The combined operation, however, offers the advantage of early weight-bearing with the limb in an extended position as soon as the osteotomy has united. This should shorten the duration of treatment to about 12 weeks. We prefer the alternative operation, a femoral osteotomy. In contrast to Ryan et al. [14], we recommend a two-stage procedure to minimise operative trauma. In a recent study, Wenger et al. [23] found the ligamentum teres to have material properties similar to those of other ligaments. The ligamentum teres contributes significantly to the stabilisation of the hip joint. Wenger et al. recommended the preservation and the transfer of the ligamentum teres to augment stability as an adjunct to open reduction. In contrast to these findings, we recommend excising the ligament along with the fatty pulvinar to assure a deep, stable reduction without obstructions. In our study we could not find any negative effects. In their study on 18 hips, Ryan et al. [14] published a good ROM with an average flexion of 104°, flexion contracture of 3°, abduction of 29°, internal rotation of 24° and external rotation of 36°. In our study we found comparable values after a mean follow-up of 32.75 years. Trendelenburg's sign was positive in five patients. The score according to Merle d'Aubigné was 16.1 (min.: 12, max.: 18). At the time of follow-up no patient had pain at rest, used crutches or a cane or needed analgesics for pain relief, which correlates with the excellent radiological results in our study. Acetabular dysplasia, defined by Severin as a centre-edge angle of less than 20°, often progresses prematurely to degenerative joint disease. Factors associated with congenital dislocation of the hip and degenerative osteoarthritis include a loss of sphericity of the femoral head, a break in Shenton's line (subluxation), a group IV growth disturbance and lack of coverage of the lateral one third of the femoral head [9]. In the study of Malvitz et al. [9] degenerative osteoarthritis also was closely associated with the patient's age at the time of the reduction, the use of an adductor tenotomy, the degree of displacement, the superior centring ratio after the reduction and the duration of follow-up. In our study delayed open reduction was performed in all cases; 35 hips had no or doubtful signs of osteoarthritis according to the Kellgren classification. Our two-stage procedure seems to be a

successful principle in the operative treatment of late developmental displacement of the hip.

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